# DRAINAGE AND NAVIGATION.

UNDER THE ACTS 5 & 6 VIC., CAP. 89, &c.

## LOUGH NEAGH DISTRICT.

REPORT of ROBERT MANNING, M.INST.C.E., Chief Engineer to H. M. Board of Public Works in Ireland, on the FLOODING of the LANDS in this DISTRICT.

I. On the 2nd day of July, 1883, I received instructions from this Board to have a careful survey made of the Lower Bann river so as to enable me to report to them on the flooding of the district and the measures which I would recommend to be adopted for the relief of lands subject thereto. The survey and necessary calculations having been completed on the first day of the present month, I now beg leave to submit the following report.

II. In the month of February, 1877, the surface of Lough Neagh rose to a much greater height; the Lower Bann river discharged a much greater quantity of water than at any time since the completion of the drainage works, and the lands were subject to very injurious flooding.

III. In the following May I was ordered to proceed to the district and report upon the causes of the flooding; on the measures which in my judgment would be necessary for the relief of the lands; and at what cost such relief could be effected.

I submitted that report to the Board on the 8th of June, 1877, and as the facts which I then collected are verified by the careful survey recently made of the river by Mr. W. J. O'Neill, C.E., and the opinions which I then ventured to express are not modified in any material point by the additional facts which that survey presents, I beg it may be taken as part of the present report.

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REPORT to the BOARD of PUBLIC WORKS on the FLOODING of LOUGH NEAGH DISTRICT in the Winter of 1876–7.

1. I beg to report that by direction of the Board I proceeded to the Lough Neagh district on the 14th ult., and upon that and the three following days I examined the state of the district from Portadown to Coleraine. Although the Board are well aware of all the facts of the case up to the time when the final awards (in respect both of drainage and navigation) were made in the year 1859, I think it well in the first place, for the better understanding of this report, to give a brief description of the works as designed and executed, and the effects produced by the drainage of the district.

2. Lough Neagh, which is nearly 100,000 acres in extent, receives waters flowing from 1,865 square miles of country. Its average surface level in summer, previous to the execution of the works, was forty-eight feet above that of low water of ordinary spring tides (in the year 1826 it fell to forty-six feet); winter floods rose to a height of from six to eight feet over ordinary summer water, or from fifty-four to fifty-six feet above low water. The only outlet for the discharge of the lake is the Lower Bann river, which flows out of the lake at Toome, and after a course of thirty-two miles discharges into the tideway at the Cutts, a rocky fall a short distance above Coleraine.

3. The quantity of land flooded by the rise of the lake and river was nearly 30,000 acres, 21,000 of which are situate above the outlet of the lake at Toome. In the month of December, 1845, the late Mr. MacMahon, C.E., submitted to the Board a report on the proposed drainage of the lands and the establishment of a navigation from the sea to Lough Neagh. He estimated the volume of ordinary winter floods at 400,000 cubic feet per minute, which he proposed to discharge at Toome at a height of 47·06 feet above low water spring tides at Coleraine (being one foot above the lowest level to which the lake had ever fallen, or one foot below the ordinary summer water of the lake), and he stated that floods might rise one foot higher without injury to the low meadow lands. The navigation was to be effected by the construction of five locks, having a depth of eight feet over their sills.

4. Mr. MacMahon's design having been approved by the Board the works were commenced in the year 1847 and were completed in 1858 with little, if any, deviation from

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tbe original desigu. Indeed the relief of the district above Portna may be dated from the completion of ths weir at Toome, and the removal of the cross dams at Portglenone in January, 1856.

5. The quantity of flooded lands above Portna, exceeded 27,000 acres, and therefore the importance of the efficient execution of the works between that point of the river and Toome, is very obvious. On the 10th of March, 1859, Mr. James Barton, C.E., examined the state of the navigation works between Toomo aud Coleraine, whicb he very minutely inspected, taking the necessary soundings and levels. Hc reported that the specified depths had been practically carried out, and in many cases more work had beon doue thau was originally contemplated, and he concluded his roport hy expressing his opinion that the navigation "works were a credit to the country as a public work," and, that, "they bear strong testimony to the skill and discretion of those who carried them out."

6. I may be permitted (after my recent inspection) to state my full concurrence in this opinion, and to add that as the excavation necessary for navigation formed a part of that required for drainage also, the efficient execution of the oue, involves to a great extent that of the other.

7. But the success of the work in regard either to design or excention, ie not a matter of mere opinion. Altbongh the award was not made until the year 1859, and the works were not entirely completed till the month of May, 1861, thoy were so far advanced at the commencement of 1854, as to give very substantial relief from floods. A daily registry has been kept of the height of the lake from that date to the present time. For the first period of eleven years the lake did uot rise above the height anticipated by Mr. MacMahon, between the 1st of March and the 1st of December, in any year, except upon two occasious, when it roso from 2 to 4 inches higher, in the months of March aud November. There were only five occasions in those elevon years, when it rose as higb as 6 inches, aud tbose were in the mouths of Decenber, January, and February. During the same period the maximum dischargo of the lake did not exceed the estimated quantity of 400,000 cubic feet per minute, except in the months of January and February, 1860 and 1862 (years of great rainfall), and then only from 4 to 7 per cent. In the second period of ten years to May, 1874, the results of the drainage was not so efficient. In nearly every year there was more or less flooding iu tho months of December, January, February, and March, and on two occasions there were slight floods in the months of Octobsr and November, but in those years there was no flooding whatever between the 1st of April and 1st of October. The quantity discharged was also increased. In December and January, 1872-3, tho maximum discharge was over 500,000 cnbic feet per minute.

8. For the third period of three years to 1st May, 1877, the floods were greater in height than observed at any previous time.

9. In February last, the lake rose 14 feet over tho upper sill of Toome lock (being 6 feet 10 inches over the lowest summer level since the execution of the works). The average discharge for the entire month of January, exceeded 600,000 cubic feet per minute, and on the 2nd and 3rd of February, it rose to 682,000 cubic foet per minute. There was uot, however, any land flooded between tho months of May and November, in these years. The facts, which I have thus shortly stated are given in more detail in the tables which I have prepared and annexed to this report.

10. Speaking gonerally it may be said that with tho exception of the present year, when flooding occurred in tbe month of April, the lande above Toome have been completely free from floods for seven months in every year, from April to Octobor, both inclusivs. It appears, then, that, cousidered as an agricultural drainage, the works, sven up to the present time (certainly, at least, with respect to all grass lands) have been successful; they were quite so up to the time of their completion, and with little exception for five or six years afterwards. But it ie this very euccess that has caused the effects of the floods of last winter to be so severely felt by the occupiers. Low lands have been turned to tillage and houses built upon them. This is especially the case in the neighbourhood of Portadown—where factories and streets of artisans' dwellings have been built on ground which, previous to ths drainage, must have been under water for months together

11. Three questions naturally arise from the etatement of facts which I have now laid before the Board:—

I. What are the causes of the flooding which has occurred of late years, and from which the lands were practically free for ten years after the execution of the works?

II. Can the lands be relieved from tbose floods?

III. What will be the cost?



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## I.—*What are the causes of the Flooding?*

In all districts, great or small, there are two principal causes of flooding—one, a large rainfall, and the other, the insufficiency of the river channels to discharge it at a low level. In small districts the maximum discharge will depend on the rainfall of a single day, or, indeed, of an hour. In large districts it will depend upon that of a month, or, in some cases, several months. So far as I have been able to investigate the laws of the discharge of the Lough Neagh district, the maximum will usually take place in the month of February, and will depend upon the rainfall of the two previous months. In the present state of the district, seven inches of rain falling in two winter months (when there is little or no evaporation) will produce a discharge which will partially flood the lands. The great flood of the 2nd and 3rd of February, 1877, was preceded by a fall of 12·30 inches in the previous two months. In addition to which the rainfall at Hilltown, near the head of the Upper Bann River for the year 1876, was 66 inches, the average being about 48 inches, and the maximum in previous years being probably not more than 55 inches,* the large rainfall would sufficiently account for the great and constant floods which occurred from December to April last, but the flooding during the previous twelve years (1864 to 1876) has, in my opinion, been mainly caused by the insufficient area of the channel from Toome to Portna. This is very apparent on examination of the levels of the water above and below Toome Weir. This weir is free from back-water till the discharge reaches about 160,000 cubic feet per minute; when it increases to 260,000 cubic feet, the back-water stands 20 inches over the lowest part of the weir, and there is then a difference of only 4 inches between head and tail water. With a discharge of 360,000, the back-water stands at a height of 34 inches over the weir; and the head is reduced to 2 inches; and at the maximum height of the flood in February last, the difference of level was only 1 inch, and the back-water rose to a height of 6 feet 11 inches over the weir.

In the month of June, 1863, Mr. O'Neill, the engineer to the Board of Drainage Trustees, measured the deposit below this weir and found that a quantity of 81,000 cubic yards of sand and silt had accumulated since the completion of the works, 14,000 cubic yards of which had been deposited in the previous year. On the 15th of May, 1877, I sounded the river channel between Toome and Portna with the following results:—

| — | Sectional Area of Channel below the level of Summer Water. | |
|---|---|---|
| | 15th May, 1877. | As shown on the Sections at the completion of the Works. |
| | Super. Feet. | Super. Feet. |
| Above Toome Weir, | 1,400 | — |
| Between Navigation Weir and First Eel Weir, | 850 | 1,420 |
| Below County Bridge, | 1,100 | 1,740 |
| At Southern End of Lough Beg, | 800 | 1,660 |
| Above Portna, | 1,600 | 1,750 |

All the circumstances stated point, therefore, distinctly to the fact that the channel at present is much less efficient than at the completion of the works; and there can be little, if any, doubt that the increased height of the water in recent years has arisen mainly, if not entirely from this cause.

* Since writing this Report, Mr. J. Smith, jun., C.E., has kindly furnished me with the registries of Rain Gauges kept by him at stations near the head of the Upper Bann:—

| — | Rain (Inches). | | |
|---|---|---|---|
| | Twelve Months, 1876. | Six Months, to 1st Feb., 1877. | Two Months, to 1st Feb., 1877. |
| Fofanny, near Castlewellan, 920 feet above the Sea, | 82·68 | 72·26 | 35·20 |
| Bann Reservoir, 440 feet above the Sea, | 52·90 | 51·70 | 24·90 |

## II.—*Can the Lands be relieved from Floods?*

After the best consideration I could give the subject, I am of opinion that it would be impossible (at least within the bounds of any reasonable expenditure) to free the lands from such floods as occurred during the past winter; but if works be executed to restore the channel between Toome and Portna to the state in which it was given up to the Trustees, there are reasonable grounds for the hope that the same successful results will arise as in the period of twelve years—from 1854 to 1866. In fact it appears to me to be a question of maintenance under the powers of the General Acts which have been put in force by the Board in several districts during the last few years.

## III.—*What will be the Cost?*

I cannot at present report under this head; to enable me to do so it is necessary that a survey of the Lower Bann should be made. I may state, however, that in cases in which the Board has ordered the execution of works in drainage districts after total neglect for twenty years or so, the cost of putting the district in order has varied from 9 to 16 per cent. of the original cost. The cost would be probably less in this district, on parts of which, at least, a considerable annual sum has been expended in keeping the works in order.

It will be observed that the statements already made in this Report apply almost exclusively to the state of the district above Toome; between that place and Portna there are more than 6,000 acres of land subject to flood, and all, or nearly all, of which must have been flooded during the last winter. As to this, it is only necessary to say that the enlargement of the channel necessary to the drainage of the lands above Toome will also effect that of the lands last mentioned. Lower down the river, between the "Cutts" and Carnroe, a quantity of more than 2,000 acres of land is subject to flood—and was flooded during the last winter. I have no hope that any material improvement can be made in the condition of those lands. I find, on examination of the papers referred to me, that the same opinion was entertained at the time of making the award. The case appears to have been well considered, and an abatement of the drainage charge made in consequence. This will appear, on comparison of the Draft Award with the final one. It will be sufficient here to say that in the case of two of the London Companies (the Mercers and the Ironmongers), the amount of the half-yearly instalments was reduced from £183 12*s.* 2*d.* to £155 17*s.*, which represented an abatement in cash of £807 4*s.* 2*d.*

I have not considered it necessary to enter into the case of the Upper Bann, nor of such lands, if any, as were flooded on tributaries above the influence of the lough; such an examination would have occupied more time than I could spare from other duties, it may be entered upon, should the Board decide upon having a more complete examination made of the district. Before closing this Report, I think it right to allude to opinions strongly expressed in some of the documents referred to me—namely, that an enlargement of the discharging capacity of the navigation weirs, below Toome, or the total abandonment of the Lower Bann navigation altogether, is all that is necessary for the complete drainage of the lands in the Lough Neagh district. This subject is very ably discussed in a Report of Mr. O'Neill, Engineer to the Drainage Trustees, dated the 27th of February, 1873. I beg to express my concurrence in the general principles laid down in that Report. It is right, however, to add that, although, in the present state of the river little, if any, effect would be produced in lowering the height of the flood-water at Toome during the continuance of a flood of 700,000 cubic feet per minute, an increase in the discharging powers of Portna Weir; a judicious application of sluicing power at that weir, combined with the restoration of the channel above it, to the full sectional area designed by Mr. MacMahon, may assist in retarding the rise of the floods and facilitating their more speedy discharge. This is a question, however, which does not admit of generalization. I shall be prepared whenever the Board wish it, to investigate the extent of relief which may be expected from the construction of sluices, and the cost of obtaining it. I cannot make a better conclusion to this Report, than to quote the words of Mr. Hancock in his letter to Mr. Hill, of the 5th of February, 1873:—

"However desirable or even necessary it may be to make further improvements, care must be taken that we do not hastily abandon what was so carefully and thoughtfully worked out as a final measure of relief."

(Signed), ROBERT MANNING, C.E.

*June 8th*, 1877.



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The foregoing Report was in the nature of a preliminary inquiry into the facts and causes of the flooding of the land in the Lough Neagh district. I, therefore, stated the facts which I gathered from a study of the daily registry of the heights of water, and from which I formed the opinions stated in a general manner in the Report. Since then the subject has been much discussed by persons interested in the drainage of the lands, and has been under the consideration of the Commissioners appointed by the Queen "to inquire respecting the system of navigation which connects Coleraine, Belfast, and Limerick."

This Commission (which was presided over by Lord Monck) reported on the 8th of February, 1882, as to the effect of inland navigation on the drainage of the country; whether it was really possible to combine both objects; and if not, "whether the present use, and possible future success of the navigations should be weighed against the immediate and continuous loss to agriculture; or whether the navigations should in some cases be abandoned."

In submitting the present Report to the Board I am unwilling it should be supposed that I have treated the opinions expressed by persons having a deep interest in the drainage of the lands of the district with disrespect, or did not give them the consideration which is due to them. I therefore hope I may be permitted to discuss more fully the facts on which I founded my opinions in my former Report in connexion with those just alluded to.

First, as to the causes of the flooding. These have been attributed to various causes, viz.:—The excess in the yearly quantity of rain above that upon which the original calculations of Mr. MacMahon were made; the improvements made in arterial and thorough drainage within the watershed of the district since the works were executed thirty years ago; the insufficiency of Mr. MacMahon's estimate of the quantity of water to be discharged, and of the channel designed to discharge it—impeded as it was by navigation weirs—and the incomplete execution of the works recommended by him.

A reference to Table No. 3, attached to this Report, will show that the average yearly rain for the last twenty years has been rather less than previously; but if this were not so, but the contrary were the fact, the same table shows that in years in which the rainfall was from 42 to 43 inches there was no flooding, while in the year 1877, in which the greatest floods occurred, the rainfall was only 38 inches. The fact is that no reliable calculation of the flood-discharge can be based upon the average yearly quantity of rainfall. I have shown in the Report of 1877 that in the present state of the Lough Neagh district it depends upon the rainfall of the previous two months. Mr. MacMahon did not base his calculations on any such data, but upon the distribution of the rainfall; observations of the actual rise of the lake in a given time; the ratio of its area to the rain-basin from which it receives its supply; the effects of increasing its range, and other matters which are necessary to be taken account of by the engineer who undertakes to control the waters of a lake the area of whose surface exceeds 150 square miles, and is supplied from a rain-basin of nearly 2,000 square miles.

With regard to the effects of arterial and thorough drainage in increasing the volume of great floods, it can be shown that in a certain combination of circumstances either one or both will do so; but a long experience has forced upon me the conclusion that, as regards Ireland at least, all drainage of the surface will increase the flood-discharge, while all thorough drainage will tend to diminish it. However this may be, the amount of arterial and thorough drainage accomplished within the watershed of Lough Neagh since the completion of the works can only have produced the most insignificant effect upon the discharge of the Lower Bann River.

As to the alleged insufficiency of Mr. MacMahon's estimate of the flood-discharge (400,000 to 500,000 cubic feet per minute), it is only necessary again to refer to Table No. 3 in order to show that it has proved practically correct until the year 1877, more than thirty years after he made it. I have already stated that such an estimate must be based, among other things, on the proposed range to be given to the lake, and consequently upon that range being maintained; whether such maintenance has been performed will presently appear when I come to consider whether Mr. M'Mahon's design was carried into execution.

In "the Report of the Commissioners of Inquiry into Arterial Drainage in Ireland upon the Lough Neagh Drainage and Navigation District," made in the year 1858, it is stated:—"The works of the district have been carried out (with some unimportant alterations in local arrangement), in entire accordance with the principles and general design laid down in Mr. MacMahon's report." On the other hand, in a report made in the year 1881 by Mr. James Barton, M.INST.C.E., which appears in the appendix to the minutes of evidence taken by Lord Monck's committee, he comes to a different conclusion During a survey and examination of the river made by him, he endeavoured to



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discriminate between the cases where Mr. MacMahon's design was not carried out, and where the transverse area of the river had been diminished by subsequent accumulations of silt; and he estimates the latter at a quantity of 68,242 cubic yards, the removal of which, he estimates, will cost £2,579 10*s.* 2*d.* I need scarcely say that this was a very difficult task to be performed correctly, and one in which two engineers equally anxious to arrive at a true result might fairly differ with each other. It is to be observed, however, that the quantity of deposit estimated by Mr. Barton refers only to the portion of it which, in his opinion, the navigation trustees were bound to remove, and does not include the quantity deposited in the weir basins, which are to be maintained by the trustees of the drainage. So far back as the year 1863 upwards of 80,000 cubic yards had then accumulated within a few hundred yards below Toome weir, 14,000 cubic yards of which had been deposited in the previous year.

It thus appears that more silting had occurred at that early date in one weir basin alone than was estimated by Mr. Barton to have taken place up to the year 1880 (seventeen years afterwards) in the bed of the Lower Bann for a length of more than thirty miles.

There cannot be any doubt whatever that notwithstanding the large quantity of silting actually measured in the year 1863, the capacity of the river for discharging floods was even then much greater than it was in the year 1877, when the highest flood on record since the completion of the works took place.

On the 18th of March, 1864, Toome weir discharged 402,000 cubic feet per minute, the head water being 9′ 1″ over the upper sill of the lock, or one foot *below* the level at which Mr. MacMahon reported that the low meadow lands would not be flooded. On the 22nd of March, 1877, the weir discharged precisely the same quantity, but at a level of 10′ 9″, being eight inches *above* the level of the low meadow lands, the level of the backwater or surface of the Lower Bann being exactly twenty-four inches higher, and the level of the lake itself twenty inches higher in 1877 than in 1864. When it is remembered that the total range of the lake as provided for by Mr. M'Mahon was only twenty-four inches, and that half of it was dissipated by neglect in maintaining the discharging channel, it is not surprising that nature provided a compensation by flooding the lands to a depth of eight inches, nor that, in the great flood of February, 1877, it was also provided, in a similar way, by the lake rising nearly four feet higher than was calculated upon.

Since the publication of my previous report various suggestions have been published for the complete drainage of the lands in the Lough Neagh district; they are all comprised in the three following proposals:—

1. To abolish the navigations, which are considered useless, and to reclaim the greater part of the area of Lough Neagh by reducing its level thirty-one feet.
2. To abolish the navigations only, by removing all the weirs, including that at Toome.
3. To lower the navigation weirs on the Lower Bann two feet, so as to reduce the navigable depth from Toome to Coleraine, which "would only bring the channels to the level of other navigations coming into Lough Neagh."

The first project was published by Mr. Charles Wilson of Cheltenham, in January, 1878, and is supported by Doctor MacCormack of Belfast, who published a letter in the month of November, 1877, giving as an example the successful drainage of *Lac Fucino* in Italy at the expense of Prince Torlonia of Rome. It is obvious that in the consideration of such a scheme as this, the purchase of the Lagan and Ulster canals, and of the Newry, Tyrone, and Upper Bann navigations must be provided for, and if the Lower Bann navigation be abolished without the consent of the ratepayers in the counties of Antrim and Londonderry (many of whom are still sanguine as to the future success of that navigation) their claims to the restitution of £37,000 contributed by them must also be taken into account. But these are not the only difficulties to be encountered. It is obvious that if the area of the lake be reclaimed it can no longer act as a regulator of floods, and the quantity of water to be dealt with will be that actually flowing into the lake at any given time. On the 7th January, 1877, that quantity amounted to 2,671,000 cubic feet per minute, and even in the years 1872–3, when the greatest quantity discharged at Toome amounted to 524,000 cubic feet in a minute, the quantity flowing into the lake on one occasion was as high as 1,790,000 cubic feet in a minute, and on several occasions it varied from 1,000,000 to 1,240,000 cubic feet per minute. I need not enter into a calculation of the expense of excavating a channel nearly four times as large as the present one, the level of which should be at least thirty feet deeper, according to this project.


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As to *Lac Fucino*, a very excellent description of that great work appeared in March, 1878, in the *Annales des Ponts et Chaussées*, from the pen of M. Alfred Durand-Claye, *Ingénieur des Ponts et Chausseés*. Thie lake is in the Abruzzi about fifty-four miles sonth of Rome. It is supposed to be the crater of an extinct volcano; it had no visible outlet, and its waters were reduced only by evaporation and infiltration. In ancient times the Emperor Claudius employed 30,000 men for eleven years in driving a tunnel through Mount Salviano so as to give an ontlet into the river Liri. In accomplishing this object it was necessary to sink forty shafts, some of which were 400 feet deep. M. Durand-Claye is perfectly just in saying that such a work is truly calculated to excite the astonishment of the engineer, when he reflects that those who nndertook it and brought it to a successful completion had neither powder nor steam, nor any of the modern mechanical appliances at their disposal. This work fulfilled the objects expected of it for some timc, but it was allowed to fall into decay, and it was only in the year 1816 that a sum of £1,700 was expended in explorations with a view to its restoration. The works undertaken by Prince Torlonia commenced in the year 1854, and were practically completed in the year 1876—a period of tweuty-two years. They consisted in the enlargement and general improvement of the ancient Roman work. The tunnel is now nearly four milee in length; it has an area of about 210 square feet, and was calculated for a discharge of 100,000 cubic feet per minute, which has, however, on some occaeione actually amounted to 140,000 cubic feet per minute.

The number of acres drained is about 40,000, and the total cost, exclusive of that of the ancient works, is about £2,000,000, or in round numbers £50 per acre.

The river Bann was designed to diecharge from 400,000 to 500,000 cubic feet per minute, its sectional area as dcsigned varied from 2,000 to 2,400 square feet, the number of acres drained is nearly 30,000, and the total cost for drainage was less than £160,000, or from £5 to £6 per acre.

To abolish the navigatious only by removing all the weirs including that at Toome is open to the objectione first mentioned undsr the last head of this report, and although I believe there is a desire on the part of some persons (who are interested in the drainage of the land alone) to removo all the weirs except that at Toome, I do not think there is one among them who now seriously desires ths removal of that weir; and moreover the Royal Commiesioners at page 13 of their report express their opinion that it should be maintained. Tho third project (proposed by Mr. Barton), to lower the weirs on the Lower Bann 2 feet, so as to reduce the level of the navigation below Tooms, and bring it to that of the other navigations coming into Lough Neagh, is free from the objections to which the two others are liable, except that of reducing the navigable depth of the Lower Bann as proposed, and this may in my opinion bs also avoided. There would be little or no advantage in lowering the snmmer level two feet, as the surfacs of the Bann from Toome to Portna is comparatively of inconsiderable extent and therefore viewed as a compensation reservoir would have no appreciable effect in reducing the volume of great floods. The winter level of the water snrface at Portna is from one to thrse feet abovc that necessary for au oight-foot navigation. Mr. Barton states in his report that to redncs the height of Portna weir two feet would have the sams practical effect on the height of floods at Portglenone as if it were altogether removed. Crest boards, two feet in depth, may be placed ou the weir which can be easily lowered whenever the water rises over the present navigation levsl, or an equivalent area of sluices can be substituted; the reduction of the height of the weir is therefore unnecessary. The idea that navigation and drainage are antagonistic to each other is certainly not the case in the Lough Neagh district. The cost of excavation charged to the navigation account, and which should have been expended for drainage purpoeee if the navigation never existed, amounted to about £44,000, and redneed the cost of drainage by more than 25 per cent. In the appendix to the report of Lord Monck's Commission (p. 138) Mr. Barton states that there is no good case for the removal of the navigation for drainage purposss, and he estimates the coet of works which would be equivalent to the entire removal of the weirs, but would still maintain a six-foot navigation, at the sum of only £5,100. In the minutes of evidence taken before the same Commission (729 *et seq.*) one of the witnesses not only proposes the total destruction of the locks and weirs, but suggests that the cost of the maintenance of the navigation which amounts to more than £1,425 a year should in future be contribnted by the ratepayers who paid £37,000 for the navigation, and ehould be applied to drainage purposes. I need not discuss in this place, the adequacy of Mr. Barton's estimatee of the maximum quantity of water to be dealt with, nor of the cost of discharging it, my opinions on these points will appear further on.

Under the eecond head of my former report I ventured to express my opinion that if works were executed to restore the channel of the river to the state in which it was


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given up to the Trustees the same successful results would arise as in the twelve years from 1854 to 1866.

After further inquiry into the subject, I am still of the same opinion. From a survey consisting of 283 transverse sections of the river I have estimated that in order to restore the channel to the original capacity designed by Mr. MacMahon a quantity of excavation amounting to 357,000 cubic yards will be required, and the cost at the sum of £25,400. Mr. Barton estimates the quantity of excavation (necessary for the discharge of 585,000 cubic feet per minute), at 298,000 cubic yards, and the cost at £18,433.

The difference between the two results arises from the fact of a closer survey having been made in one case than in the other.

I stated in my previous report that the cost of maintenance in drainage districts, after total neglect for twenty years or so, varied from 9 to 16 per cent.

In this case it would be, by my estimate, 12½ per cent., and according to Mr. Barton a little over 9 per cent.

In the Report of the Commissioners of Inquiry (page 7), it is stated that:—

"The lands formerly under the destructive influence of floods have been relieved from all future liability to injury with the exception of about 600 acres of the bed of Portmore lake which had been found too low to receive much advantage; and some other very low-lying lands—nearly 2,000 acres on the Upper Bann and on the Tall and Callan Rivers which are yet occasionally after heavy rains for a short time subject to be inundated notwithstanding the additional advantage of outfall which in the case of the latter rivers—by a deviation in their conjoined course their joint discharge is carried five miles lower down the Blackwater River than was originally contemplated—was conferred."

It is further stated that 4,358 acres were reclaimed from the former beds of Lough Neagh and Lough Beg and I have ascertained that 658A. 1R. and 33P. of these lands were sold by the Board (freed from all contribution whatever towards the cost of the works) for the sum of £1,445 15*s.* or £2 4*s.* an acre, and are now only liable to contribute towards the maintenance of the district. These lands were purchased in the year 1870, eleven years after the award was made.

These lands are necessarily at a very low level and are the first to suffer from floods, except perhaps where extensive turf-cutting has taken place either before or after the execution of the works, and the cut-away bog has been reclaimed.

In the report of 1877 I expressed the opinion that it would be impossible (at least within the bounds of any reasonable expenditure) to free the lands from such floods as occurred in the previous winter. The expediency or otherwise of the expenditure of money for the relief of the lands from such a flood as occurred in that year is a matter entirely for the consideration of the owners of those lands. To enable them to come to a decision I have calculated from the daily records of the height of the lake and from the calculated daily discharge over Toome weir—the maximum quantity of water to be discharged and the cost of discharging it under the level of the lands.

On the 14th of November, 1876, Lough Neagh was only 4 inches over summer level and the weir was free from back-water, except the low part in the middle for the discharge of the summer water, on which there was a depth of only 6 inches, and the weir was discharging 171,000 cubic feet per minute.

The quantity of water flowing into the lake and which produced the great flood of February, 1877, is given in the following table:—

| Period. | Time, Days. | Average Quantity, Cubic feet per minute. |
|---|---|---|
| 2nd December, 1876, to 14th December, 1876, . | 12 | 732,000 |
| 14th December, 1876, to 31st December, 1876, . | 17 | 717,000 |
| 31st December, 1876, to 9th January, 1877, . | 9 | 954,000 |
| 9th January, 1877, to 27th January, 1877, . | 18 | 816,000 |
| 27th January, 1877, to 3rd February, 1877, . | 7 | 1,000,000 |
| | 63 | 813,000 |

It therefore appears that for the above period of say two months, the average quantity of water to be dealt with by discharge over Toome weir and by storage in the lake is 813,000 cubic feet per minute. From the above data I have calculated that if the water was allowed to rise to the level of the low meadow lands along the Upper Bann and Blackwater as shown on Mr. MacMahon's section, and the capacity of the Lower Bann was capable of discharging 514,000 cubic feet per minute with the lake at summer level, the flood would have passed off without injury to the lands on the 3rd February, 1877, the lake being then quite full, and the discharge at Toome being 824,000 cubic feet per minute. I estimate that to accomplish this result would involve an expenditure of £202,700.



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I stated in 1877 that so far as I had then been able to investigate the laws of the discharge of the Lough Neagh district the maximum would depend upon the rainfall of the previous two months; from the facts just stated it appears that calculations of that discharge must be based (as might be expected) on the quantity of water flowing into the lake during a similar period.

Whether it is expedient to provide for the discharge of such a flood as that which occurred in February, 1877, and which much exceeded any other (before or since) for a period of thirty years, is a question which I am unable to answer, and must leave it for others who are more competent to decide; but an engineer may be fairly asked to state what works for the improvement of the district he would propose to execute if left to his own judgment. After a very careful and anxious consideration of the facts now laid before the Board, I beg to make the following recommendations:—

First.—The channel of the Lower Bann should be restored to the capacity designed by Mr. MacMahon.

Secondly.—The discharge of the weirs at Toome, Portna, and the "Cutts," should be rendered more effective by the construction of powerful sluices in each of them.

Thirdly.—Additional excavations should be made at Loughin Island; and the lower parts of the Macosquin, Ahadowey, and Agivey tributaries should be improved and embanked.

Fourthly.—In order to moderate the effects of such a flood as that of 1877, and of other exceptional floods of less volume in a greater degree, additional excavation in rock should be made above Portna weir, so as to render the increased power of discharge by the sluices more effective.

I estimate the cost of those works as follows:—

| | £ | | £ | | £ |
|---|---|---|---|---|---|
| No. 1, | 25,400 | | | | 25,400 |
| „ 2, | 18,600 | + | 25,400 | = | 44,000 |
| „ 3, | 12,000 | + | 44,000 | = | 56,000 |
| „ 4, | 39,000 | + | 56,000 | = | 95,000 |

It may be a matter of some interest if I give here the cost per acre of the drainage of this district:—

| | Cost per Acre | |
|---|---|---|
| | Exclusive of free grant. | Total. |
| | £ s. d. | £ s. d. |
| 1. Original Works as designed by Mr. MacMahon, | 3 14 3 | 5 7 2 |
| 2. Same including 30 years Maintenance (1s. per acre), | 4 11 3 | 6 4 7 |
| 3. Original Works, Maintenance and Sluices, | 5 4 1 | 6 17 2 |
| 4. Same as No. 3, with additional excavation at Loughin Island, &c. | 5 12 2 | 7 5 3 |
| 5. Same as No. 4, with additional rock excavation at Portna, | 6 18 4 | 8 11 7 |
| 6. Same as No. 5, with additional works to discharge the great flood of February, 1877. | 10 11 4 | 12 4 5 |

There have been more than 150 districts drained in Ireland, great and small, under the provisions of the Drainage Acts, the results of which clearly show the general fact that, as the size of the district increases, so does the cost per acre. I need not make individual comparisons here; if such are desired, they can be made by an inspection of the appendix to the Board's annual reports presented to Parliament. It is enough to say that the expenditure per acre on the Lough Neagh district has been much less than in most, if not all others, whatever their size.

I cannot close this Report without acknowledging the valuable assistance which I have received from Wm. J. O'Neill, C.E., in making the survey, and in placing at my disposal the many valuable facts which he had collected during the many years in which he has acted as engineer to the Drainage Trustees; nor can I refrain from expressing the great gratification it has given me to find that the respect which I entertained as a very young man, long years ago, for the opinions of Mr. MacMahon, and the able men with whom he was associated, was not misplaced, but has had a remarkable confirmation in the results disclosed by the searching investigations which it has been my duty to make in preparing this Report for the consideration of the Board.

ROBERT MANNING.

OFFICE OF PUBLIC WORKS, DUBLIN,
March 18, 1884.





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## TABLE No. 1.

Showing the Height of Water in Lough Neagh, above the Upper Sill of Toome Lock, and the Rainfall of the previous Two Months and Previous Years.

| Height. | | Date. | Rainfall. | |
|---|---|---|---|---|
| | | | Two Months. | Twelve Months. |
| Ft. | In. | | | |
| 10 | 11 | February, 1865, . . . | 6·42 | 34·82 |
| 11 | 1 | ,, 1869, . . . | 7·99 | 29·59 |
| 11 | 1 | December, 1862, . . . | 7·89 | 37·34 |
| 11 | 2 | January, 1860, . . . | 6·76 | 30·12 |
| 11 | 2 | February, 1862, . . . | 8·37 | 43·20 |
| 11 | 4 | January, 1878, . . . | 6·84 | 37·85 |
| 11 | 5 | February, 1866, . . . | 9·02 | 37·93 |
| 11 | 10 | December, 1875, . . . | 10·97 | 28·73 |
| 12 | 2 | February, 1867, . . . | 9·71 | 34·10 |
| 12 | 6 | ,, 1873, . . . | 9·36 | 39·66 |
| 12 | 8 | ,, 1883, . . . | 7·37 | 39·65 |
| 14 | 0 | ,, 1877, . . . | 12·30 | 33·25 |

## TABLE No. 2.

Showing the Discharge from Lough Neagh at Toome, and the Height of the Water over the Upper Sill of the Lock for Seven Months, September, 1876, to March, 1877, both inclusive.

| — | Discharge Cubic Feet per Minute. | | | Height of Gauge. | | |
|---|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | Maximum. | Minimum. | Mean. |
| 1876. | | | | | | |
| September, . . | 75,000 | 17,000 | 47,000 | 7·9 | 7·2 | 7·6 |
| October, . . | 282,000 | 75,000 | 205,000 | 9·3 | 7·9 | 8·8 |
| November, . . | 273,000 | 188,000 | 225,000 | 9·2 | 8·4 | 8·10 |
| December, . . | 446,000 | 264,000 | 392,000 | 11·6 | 9·1 | 10·8 |
| 1877. | | | | | | |
| January, . . . | 635,000 | 498,000 | 605,000 | 13·9 | 12·3 | 13·4 |
| February, . . | 682,000 | 514,000 | 557,000 | 14·0 | 12·5 | 12·10 |
| March, . . . | 514,000 | 397,000 | 444,000 | 12·5 | 10·8 | 11·5 |

## TABLE No. 3.

Showing the dates at which the discharge at Toome exceeded 400,000 Cubic feet per Minute, and the quantities discharged in thousands of Cubic feet per Minute between May, 1854, and May, 1877; also the Rainfall at Armagh.

| — | January. | February | March. | April. | May. | June. | July. | August | September. | October. | November. | December. | Rain at Armagh | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Inches | Average Rain. |
| Period of 11 years to May, 1864. | | | | | | | | | | | | | | |
| 1854, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 36·61 | 34·69 |
| 1855, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 24·79 | |
| 1856, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 25·20 | |
| 1857, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 33·81 | |
| 1858, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 32·01 | |
| 1859, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 30·12 | |
| 1860, . . . | 427 | 416 | — | — | — | — | — | — | — | — | — | — | 35·19 | |
| 1861, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 43·2 | |
| 1862, . . . | 427 | 416 | — | — | — | — | — | — | — | — | — | — | 42·05 | |
| 1863, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 39·00 | |
| 1864, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 34·82 | |
| Period of 10 years to May, 1874. | | | | | | | | | | | | | | |
| 1865, . . . | — | 413 | — | — | — | — | — | — | — | — | — | — | 37·93 | 31·38 |
| 1866, . . . | 441 | 427 | — | — | — | — | — | — | — | — | — | — | 34·10 | |
| 1867, . . . | 438 | 490 | 407 | — | — | — | — | — | — | — | — | — | 36·78 | |
| 1868, . . . | — | — | — | — | — | — | — | — | — | — | — | — | 29·59 | |
| 1869, . . . | — | 421 | 402 | — | — | — | — | — | — | — | — | — | 29·64 | |
| 1870, . . . | 416 | — | — | — | — | — | — | — | — | — | — | — | 22·29 | |
| 1871, . . . | — | 412 | — | — | — | — | — | — | — | — | — | — | 28·40 | |
| 1872, . . . | 412 | 446 | 431 | — | — | — | — | — | — | — | — | 524 | 39·66 | |
| 1873, . . . | 524 | 490 | — | — | — | — | — | — | — | — | — | — | 26·08 | |
| 1874, . . . | — | — | — | — | — | — | — | — | — | — | — | 416 | 28·73 | |



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## TABLE No. 3—*continued.*

Showing the Dates at which the discharge at Toome exceeded 400,000 Cubic feet per Minute, and the quantities discharged in thousands of Cubic feet per Minute between May, 1854, and May, 1877; also the Rainfall at Armagh.

| — | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Rain at Armagh. Inches. | Rain at Armagh. Average Rain. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Period of 3 years to May, 1877. | | | | | | | | | | | | | | |
| 1675, | 461 | 461 | – | – | – | – | – | – | – | – | 465 | 416 | 34·22 | 35·14 |
| 1676, | – | – | 416 | – | – | – | – | – | – | – | – | 441 | 33·25 | |
| 1677, | 540 | 632 | 616 | 421 | – | – | – | – | – | – | – | – | 37·96 | |
| Period of 6 years to January, 1884. | | | | | | | | | | | | | | |
| 1878, | 436 | 461 | – | – | – | – | – | – | – | – | – | – | 28·59 | 33·47 |
| 1879, | – | – | – | – | – | – | – | – | – | – | – | – | 35·35 | |
| 1880, | – | – | – | – | – | – | – | – | – | – | – | – | 32·64 | |
| 1881, | – | – | – | – | – | – | – | – | – | – | – | – | 61·46 | |
| 1882, | – | – | – | – | – | – | – | – | – | – | 412 | 421 | 37·92 | |
| 1883, | 470 | 540 | 481 | – | – | – | – | – | – | – | – | – | 34·94 | |

## TABLE No. 4.

Number of Days in each of the following Months and Years when the level of the Lake was above 48·06 (the level at which it would not injure the low meadow lands).

| — | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1864, | – | – | – | – | – | – | – | – | – | – | – | 20 |
| 1865, | 3 | 27 | 17 | – | – | – | – | – | – | – | – | 15 |
| 1866, | 27 | 28 | 5 | – | – | – | – | – | – | – | – | 24 |
| 1867, | 31 | 28 | 7 | – | – | – | – | – | – | – | – | – |
| 1868, | – | 3 | 6 | – | – | – | – | – | – | – | – | 7 |
| 1869, | 27 | 27 | 22 | – | – | – | – | – | – | – | – | 7 |
| 1870, | – | 15 | – | – | – | – | – | – | – | 9 | 9 | – |
| 1871, | 22 | 29 | 1 | – | – | – | – | – | – | – | – | – |
| 1872, | 14 | 29 | 21 | 5 | – | – | – | – | – | 5 | 24 | 31 |
| 1873, | 31 | 22 | – | – | – | – | – | – | – | – | – | – |
| 1874, | – | – | – | – | – | – | – | – | – | – | – | 24 |
| 1875, | 31 | 22 | – | – | – | – | – | – | – | – | 29 | 10 |
| 1876, | – | – | 29 | 1 | – | – | – | – | – | – | – | 26 |
| 1877, | 31 | 28 | 31 | 26 | – | – | – | – | – | – | 7 | 31 |
| 1878, | 31 | 21 | – | – | – | – | – | – | – | – | – | – |
| 1879, | 7 | – | – | – | – | – | – | – | – | – | – | – |
| 1880, | – | – | – | – | – | – | – | – | – | – | – | – |
| 1881, | – | 3 | 10 | – | – | – | – | – | – | – | – | – |
| 1882, | 14 | – | – | – | – | – | – | – | – | – | 6 | 61 |
| 1883, | 31 | 26 | 21 | – | – | – | – | – | – | – | – | – |



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